130C-1

MEASURING

AG 130-C

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the standard measurements using a tape measure, ruler, yardstick, and micrometer. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Understand basic terms used in measuring.
2. Identify different types of measuring tools.
3. Measure objects correctly with a ruler, tape, or framing square.
4. Measure to within 1/16 of an inch with a ruler.
5. Calculate area and volume when given dimensions using Standard measurements.
6. Read and measure with a micrometer within 1/1000.

130C-2

MEASURING

A. Measuring is essential to the design and construction of landscapes, facilities, buildings and equipment. Measuring is used to:

1. Create drawings, plans or models of projects to be built.
2. Measure and cut materials to size.
3. Place materials properly in construction.
4. Select proper size replacement parts for tools and equipment.
5. Determine quantity of materials needed for projects.
6. Calculate area and volume.

B. Common measuring tools and their uses:

1. Ruler or Yardstick - rigid measuring devices. Specialized rules or scales are made for drawing or drafting.
2. Tape Measure - flexible measuring device typically used in construction and landscaping. Large tape measures are available for measuring large areas such as field plots.
3. Framing Square - L shaped measuring device used in construction. Useful for drawing right angles on materials to be cut.
4. Calipers - pincher like measuring devices used to measure the diameter of objects.
5. Micrometers - exceptionally accurate calipers for making very small measurements. Often used in machinery repair and in the construction of precision tools.
6. Surveyors rod - used with a sight level or transit to measure vertical height. Important for leveling building sites, preparing forms for concrete, grading roads and ditches, laying pipe.

C. Units of measurement:

1. English Fractional Rule - Inches are divided into 8, 16, 32 or 64 equal segments.
2. English Decimal rule - Inches are divided into 10 or 100 equal segments.
3. Metric Rule - Basic unit of length is the meter. Each meter is divided into 100 centimeters. Each centimeter is divided into 10 millimeters.
4. See Tables 1-3 for a comprehensive listing of units of linear, square and cubic measurements for the English (Table 1) and Metric (Table 2) systems. Table 3 lists equivalencies of Metric and English units useful for converting measurements between systems.

D. Understanding Metric Measurements

1. The metric system has the advantage of being a completely decimal system.
2. The units of measure in the metric system relate to one another by multiples of ten. This makes the metric system mathematically logical and easy to use.
3. Instead of working with complicated division and multiplication to change from one measurement unit to another, the decimal point is merely moved.

    a. To change sizes of metric units, multiply or divide by 10, 100, 1,000 or 1,000,000, which is as simple as moving a decimal point.
    b. For example, to change 357 centimeters to meters, divide by 100. The answer is obvious without figuring--3.57 meters. Metric measures make calibration of instruments and equipment much easier.

4. Below is a table of metric prefixes whose meaning indicates whether to multiply or divide when changing measurement:

    a. Mega- = 1,000,000 times the basic unit (meter, liter, grams).
    b. Kilo- = 1,000 times the basic unit.
    c. Hecto- = 100 times the basic unit.
    d. Deca- = 10 times the basic unit.
    e. Deci- = 1/10 times the basic unit.
    f. Centi- = 1/100 times the basic unit.
    g. Milli- = 1/1000 times the basic unit.
    h. Micro- = 1/1,000,000 times the basic unit.

ACTIVITY:

1. Add and subtract both English and metric units of measure; then discuss the use of common fractions in English unit manipulation and the use of decimals in metric unit manipulation.
2. Perform English-to-metric and metric-to-English conversions.
3. Compare U.S. standard measure and metric measure tools and identify engines and machinery which require metric measure tools.

Table 1. English Units of Measure

Linear Units (Length)

12 inches (in. or ")	=	1 foot (ft or ')
3 feet	=	1 yard (yd)
16 1/2 feet	=	1 rod (rd)
5 1/2 yards	=	1 rod
320 rods	=	1 mile (mi)
5,280 feet	=	1 mile
1,760 yards	=	1 mile
1 furlong (fur)	=	1/8 mile or 660 feet

Square Units (Area)

144 square inches (sq. in. or $in.^2$)	=	1 square foot (sq. ft or ft^2)
9 square feet	=	1 square yard (sq. yd or yd^2)
30 1/4 square yards	=	1 square rod (sq. rd or rd^2)
160 square rods	=	1 acre (A)
43,560 square feet	=	1 acre
640 acre	=	1 square mile (sq. mi or mi^2)

Cubic Units (Volume)

1,728 cubic inches (cu in. or $in.^3$)	=	1 cubic foot (cu ft or ft^3)
27 cubic feet	=	1 cubic yard (cu yd or yd^3)
128 cubic feet	=	1 cord (cd) - measure of fire wood

Table 2. Metric Units of Measure

Linear Units (Length)

1 kilometer (km)	=	1,000 meters
1 hectometer (hm)	=	100 meters
1 decameter (dkm)	=	10 meters

Square Units (Area)

1 square centimeter (cm^2)	=	100 square millimeters (mm^2)
1 square decimeter (dm^2)	=	100 square centimeters (cm^2)
1 square meter (m^2)	=	10,000 square centimeters (cm^2)
10,000 square meters	=	1 hectare

Cubic Units (Volume)

1 cubic centimeter (cm^3)	=	1,000 cubic millimeters (mm^3)
1 cubic meter (m^3)	=	1,000,000 cubic centimeters (cm^3)
1,000 cubic centimeters	=	1 cubic decimeter (dm^3)
1,000 cubic centimeters	=	1 liter (l)
1 cubic centimeter (cc)	=	1 milliliter (ml)

Table 3. English to Metric Conversions

Linear Units (Length)

1 in	= 25.4 mm	or	1 mm	=	0.03937 in
1 in	= 2.54 cm	or	1 cm	=	0.3937 in
1 ft	= 30.48 cm	or	1 m	=	39.37 in
1 ft	= 0.3048 m	or	1 m	=	3.281 ft
1 yd	= 0.9144 m	or	1 m	=	1.0936 yd
1 mi	= 1.6093 km	or	1 km	=	0.6214 mi

Square Units (Area)

1 in^2	= 6.452 cm^2	or	1 cm^2	=	0.1549 in^2
1 ft^2	= 0.0929 m	or	1 m^2	=	10.76 ft^2
1 yd^2	= 0.8361 m^2	or	1 m^2	=	1.196 yd^2
1 mi^2	= 259 ha				
1 mi^2	= 2.589 km^2				
1 acre	= 0.4047 ha		1 ha	=	2.471 acres

Cubic Units (Volume)

1 in^3	= 16.387 cm^3	or	1 cm^3	=	0.06102 in^3
1 ft^3	= 0.0283 m^3	or	1 m^3	=	35.32 ft^3
1 yd^3	= 0.7646 m^3	or	1 m^3	=	1.208 yd^3

To convert units, multiply unit on left by conversion factor on right.
(e.g. 10 in x 25.4 mm/in = 254 mm)

130C-7

CALCULATING AREA AND VOLUME

A. Calculating Area

1. Square measure is a system for measuring area. The area of an object is the amount of surface contained within defined limits. For example, use a square that covers four square inches.

    a. The perimeter of the square is the total length of its sides.

    $$\text{perimeter} = P = 2 \times \text{length} + 2 \times \text{width}$$

    $$= (2 \times 2) + (2 \times 2) = 8 \text{ in}$$

    b. The area of a square or rectangle is equal to the length times the width.

    $$A \text{ (area)} = \text{length} \times \text{width}$$

    $$= 2 \times 2 = 4 \text{ in}^2$$

2. Finding the area of circles.

    a. The perimeter of a circle is equal to the diameter (D) of the circle times pi (▲). ▲ is the ratio of a circle's perimeter to its diameter. This ratio is 22/7 or approximately 3.14. Pi is constant for all circles. The perimeter of a circle is known as its circumference.

    Perimeter of a circle = ▲ x D = 3.14 x D

    b. The area of a circle is equal to pi times the radius squared. The radius of a circle is half the diameter:

    Area of a circle = ▲ x R^2

    c. For example, a circular grain silo has round floor 18 feet in diameter.

    The perimeter (circumference) of the floor is
    Perimeter = 3.14 x 18 = 56.52 feet

    The area of the floor is
    Area = 3.14 x (9 x 9) = 3.14 x 81 = 254.34 ft^2

3. Finding the area of the curved surface of a cylinder.

a. The curved-surface area of a cylinder is equal to the circumference (▲ x D) of an end times the height (H).

Area of a cylinder = A = (▲ x D) x H

b. Example - If the silo in the example above is 50 feet tall:

The area of the sides of the silo is:
Area = (3.14 x 18) x 50 = 2826 ft^2

4.Finding the area of a triangle.

a. The area of a triangle is equal to one half the base (B) times the height (H).

Area = 1/2 x (base x height)

b. Example - what is the area of the triangular wall of a storage shed with a base of 2 meters and a height of 3 meters

The area of the wall is:
Area = 1/2 x (2 x 3) = 3 m^2

ACTIVITY:

1. Take actual measurement of plots and fields around the school shop or farm and determine individual and total acreage.
2. Determine how much sheet metal was used in constructing a barrel, feed bin, etc. Calculate the amount of paint required to paint the inside and outside of the silo in the example above.

B. Calculating Volume

1. A cubic measure is a system of measurement of volume or capacity of an object expressed in cubic units. A cubic measure requires three dimensions:

a. Linear measure adds only one dimension to find total distance.
b. Square measure multiplies two dimensions to find area of a surface.
c. Cubic measure multiplies three dimensions (length, width, and height) to find the volume of various types of structures and containers.

d. When determining the volume of an object, all measurements must be expressed in the same units of measurement.

2. Finding the volume of rectangular solids and cubes.

a. The volume of a rectangular solid is equal to the length (L) times the width (W) times the height (H).

Volume of a rectangular solid = L x W x H

b. Example - Determine the volume of the rectangular crate

Volume = 6' x 4' x 4' = 96 ft^3

c. A cube is a special rectangular solid where length = width =height.

d. The volume of a triangular prism is equal to the area of the triangle times the length of the prism.

3. Finding the volume of cylinders and cones.

a. The volume of a cylinder is equal the area of the circular base (▲ x R 2) times the height (H) of the cylinder.

Volume of a cylinder = (▲ x R 2) x H

b. The volume of a cone is equal to 1/3 times the area of the circular base (▲ x R^2) times the height (H) of the cone.

Volume of a cone = 1/3 x (▲ x R^2) x H

ACTIVITY:

1. Measure various rectangular and cylindrical containers or buildings and determine their volumes.
2. Measure a paper-cone cup and calculate how much water it can hold.

RULES, YARDSTICKS, AND TAPE MEASURES

A. Ruler

1. Rules come in a variety of body lengths, most commonly 6 - 12 inches, sometimes 13 inches if metric measurements are on the other side.

    a. An inch is a unit of measurement used in the United States
    b. Usually divided into 8, 16, or 32 segments (Page 130C-14)

2. 12 inches equals 1 foot.
3. 3 feet equals 1 yard
4. Rules are mostly used for measuring and drawing straight lines in drafting and sketching.

B. Yardsticks

1. Yardsticks have a body length of 36 inches equaling 3 feet, sometimes 3 feet and 3 inches if metric measurements are on the other side equaling one meter
2. Yardsticks are mostly used in measuring the length of cloth products and the water level in open top water tanks.

C. Tape Measures

1. Tape measures are flexible measuring devices and come in a large variety of lengths

    a. 10 ft, 16 ft, 20 ft, 25 ft, 30 ft, 50 ft, 100 ft, etc.

2. Tape measures are mainly used in construction, framing, fabrication, landscape layouts, surveying, etc.
3. Marks on the tape measure

    a. Foot marks, every 12 inches along a tape measure there will be a marker to indicate the distance in feet. There will be a mark at 12 inches, 24 inches, 36 inches, etc.
    b. Spacing Studs, studs used in framing walls are on 16-inch centers. At 16-inch intervals on a tape measure there will be a mark to indicate the spacing of studs. There will be a mark at 16 inches, 32 inches, 48 inches, etc.
    c. Truss marks, every 19 $^{3/16}$ inches along a tape measure there will be a small black diamond. This indicates the center for trusses.

130C-11

CALIPERS AND MICROMETERS

A. Calipers

1. Definitions

a. Calipers are instruments used to measure the diameter or thickness of an object
b. Both inside and outside calipers are used

1) Inside calipers measure inside distances such as the diameter of an engine cylinder
2) Outside calipers measure the outside of round objects such as crankshafts

2. Reading Calipers

a. Many economical calipers are not direct-reading measuring tools but require a separate rule or scale to measure their settings

1) Such calipers are used as measurement transfer tools similar to small-hole and telescoping gauges
2) They transfer the internal measurement of an engine part to a micrometer caliper for precision reading

b. More expensive calipers have their own dimension scales
c. A slide caliper (vernier caliper) is a direct-reading measuring instrument used to make fast, accurate measurements

B. Micrometers

1. Definitions and Parts Identification (Page 130C-22)

a. The micrometer is a direct-reading, precision measuring tool, which can measure to 0.001 inch (one thousands of an inch)

1) Micrometers come in various sizes for different size objects
2) They are very delicate and are ruined if dropped

b. To use a micrometer properly, the mechanic should be able to identify its' parts

2. Using and Reading a Micrometer

a. Zeroing out the micrometer

1) Screw the adjusting nut in until the zeros on the sleeve and thimble line up. Note the tightness of the adjusting nut, the same tightness will be used when taking measurements.
2) Micrometers 2 inch or larger will need a standard to be zeroed out

b. To measure with a micrometer, place the object to be measured between the anvil and the spindle

1) Screw the spindle until it touches the object

a) Adjust the micrometer to the same tightness as when the micrometer is zeroed out
b) Over tightening will ruin the micrometer and take inaccurate measurements

3. Reading the micrometer

a) Identify the frame size of the micrometer being used and write down the smallest number of inches that can be read

1) If the micrometer has a 1-to-2 inch frame, write down 1.000 in.
2) One inch is already given since the anvil and the spindle can be no closer together than one inch

b) Every revolution of the thimble is equal to 0.025 in. (twenty-five thousandths of an inch)
c) List the number of tenths of an inch (hundred thousandths) indicated by the largest number visible between the sleeve
d) Count the number of lines easily visible between the last tenths marking and the thimble then multiply the number by 0.025
e) Locate the line of the thimble that matches the horizontal line on the sleeve and write its' number down in thousandths of an inch
f) Total the values

References:

Cooper, E. L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Hokanson, C. M. (1984). APPLIED PROBLEMS IN MATHEMATICS FOR AGRICULTURE. Danville, IL:

THE STARRETT BOOK FOR STUDENT MACHINISTS,(1998) The L. S. Starrett Company, Athol, Massachusetts 01331

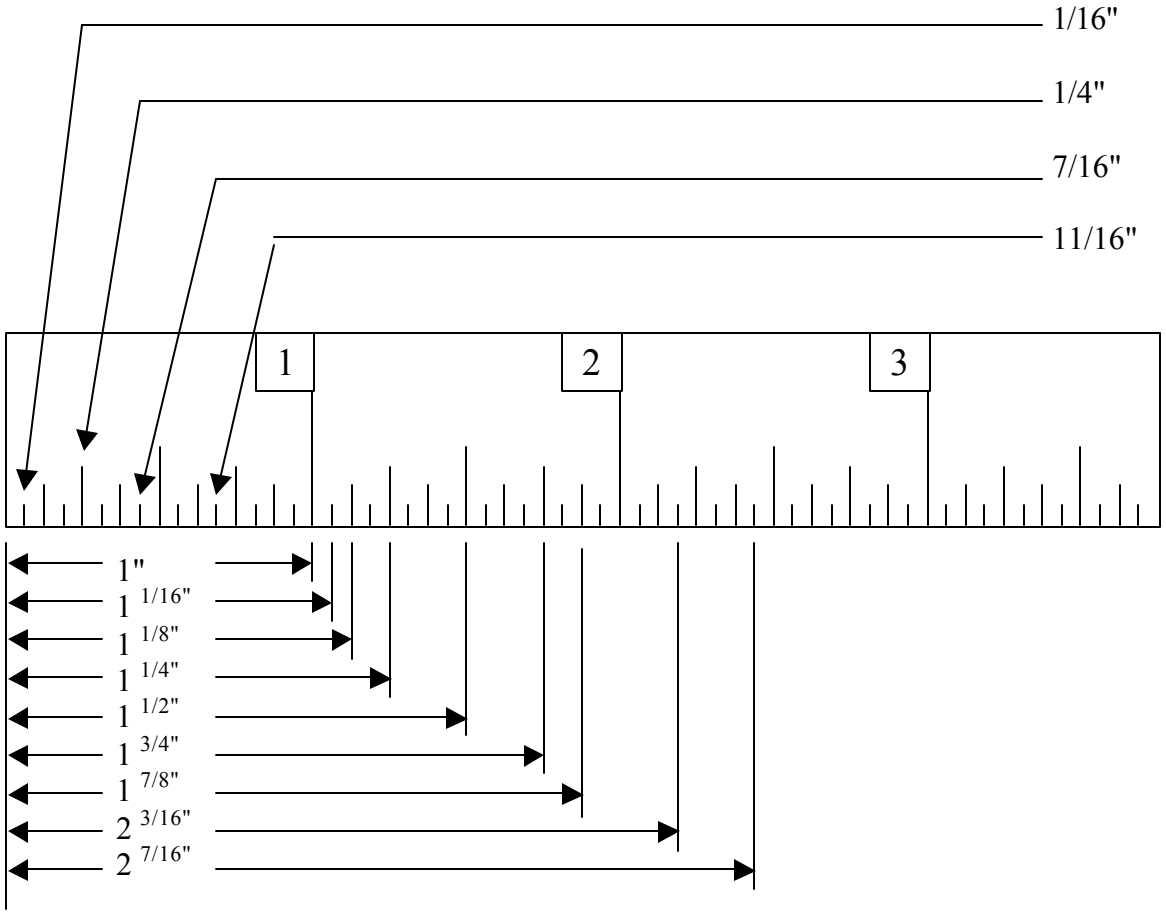
Special Material and Equipment:

Ruler or Yardstick, Tape Measure, Framing Square, Calipers, Micrometer, Calculators (optional), 25' measuring tape, objects and land to measure

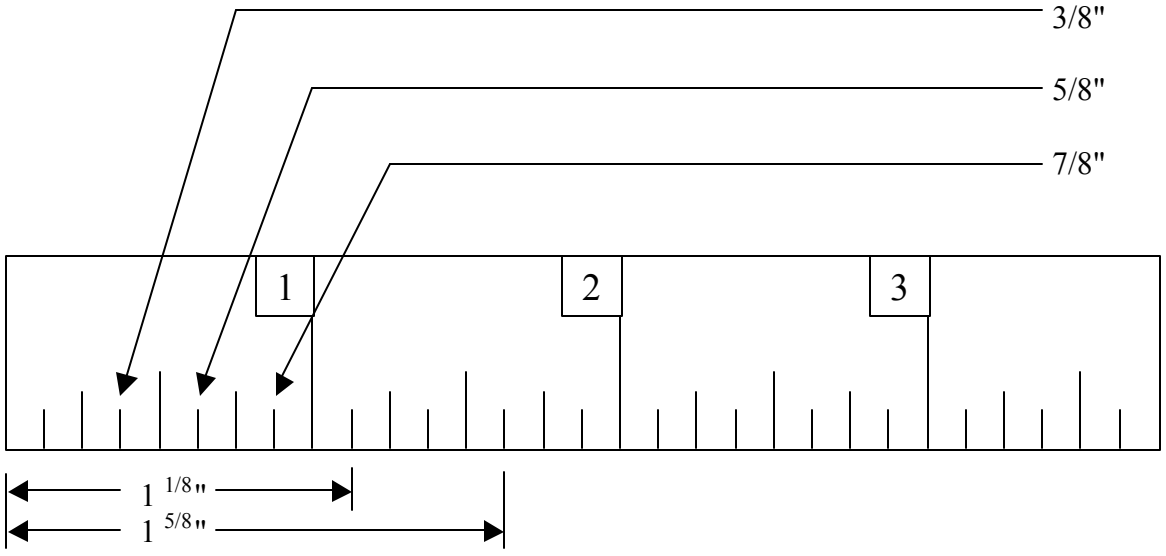
130C-14

MEASURING WITH A RULER

1/16th INCH SCALE

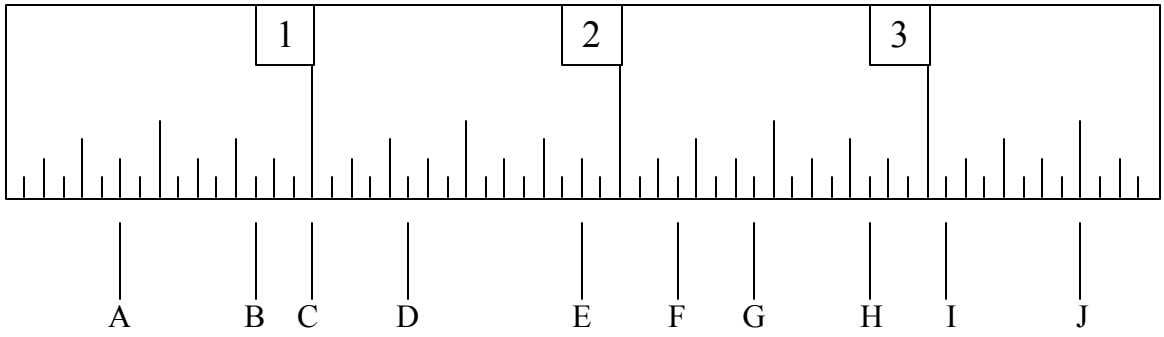


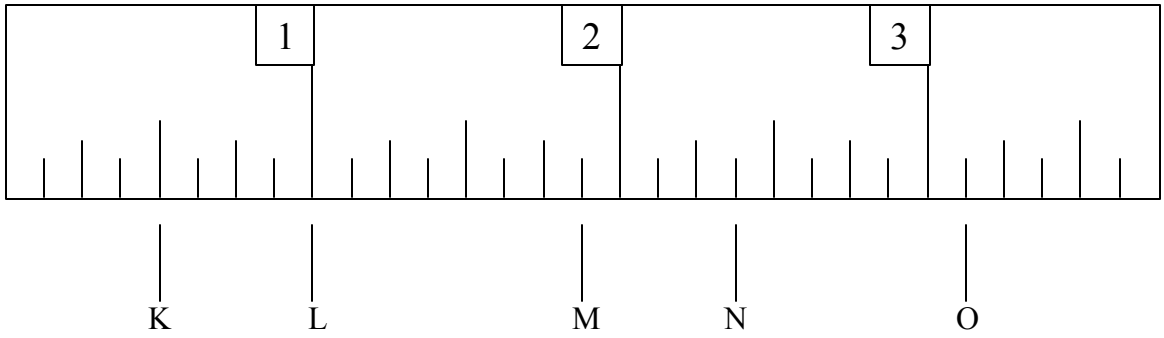
1/8th INCH SCALE



130C-15

MEASURING WITH A RULER, WORKSHEET





Write down the measurements for the location at each letter.

1. A=_____
2. B=_____
3. C=_____
4. D=_____
5. E=_____
6. F=_____
7. G=_____
8. H=_____
9. I=_____
10. J=_____
11. K=_____
12. L=_____
13. M=_____
14. N=_____
15. O=_____

Measure lines 16 through 20 to the nearest $1/16^{th}$ and record the results.

16. _____ 16=_____

17. _____ 17=_____

18. _____ 18=_____

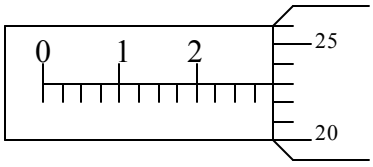
19. _____ 19=_____

20. _____ 20=_____

READING THE MICROMETER

Picture shows only the sleeve and part of the thimble
Measure to the nearest one thousandth.

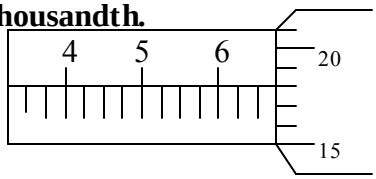
Example A
0 – 1 inch micrometer



Sleeve Reading:	0.200 inch
	0.025 inch
	0.025 inch
	0.025 inch
Thimble Reading:	0.023 inch
Total Reading:	0.497 inch

Measure to the nearest one thousandth.

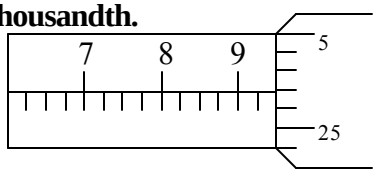
Example B
1 – 2 inch micrometer



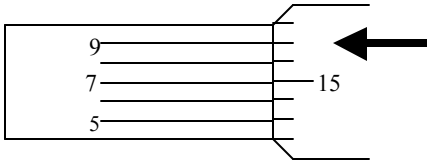
1 – 2 inch micrometer =	1.000 inch
Sleeve Reading:	0.600 inch
	0.025 inch
	0.025 inch
Thimble Reading:	0.018 inch
Total Reading:	1.668 inches

Measure to the nearest ten thousandth.

Example C
2 – 3 inch micrometer



Top View, Vernier Scale



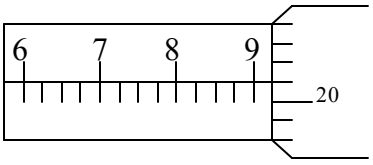
2 – 3 inch micrometer:	2.0000 inch
Sleeve Reading:	0.9000 inch
	0.0250 inch
	0.0250 inch
Thimble Reading:	0.0010 inch
Vernier scale:	0.0009 inch
Total Reading:	2.9519 inches

130C-17

MICROMETER WORKSHEET

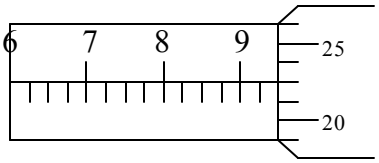
Fill in the correct measurement in the blank.
Measure to the nearest one thousandth.

0 – 1 inch



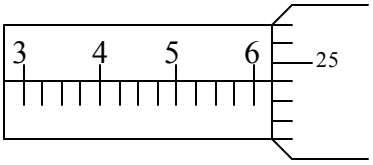
1. _____

0 – 1 inch



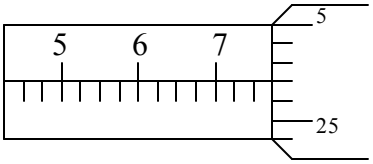
2. _____

1 – 2 inch



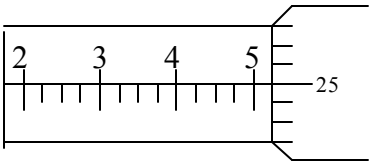
3. _____

1 – 2 inch



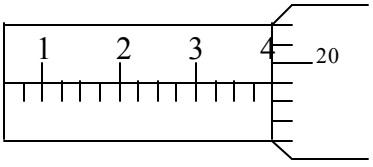
4. _____

0 – 1 inch



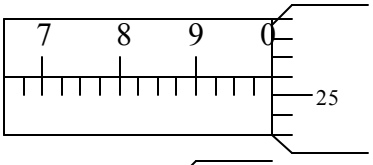
5. _____

2 – 3 inch



6. _____

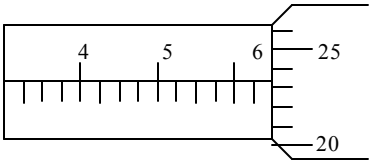
0 – 1 inch

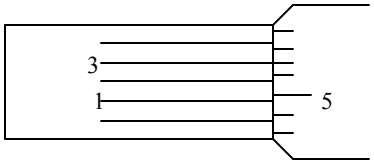


7. _____

Ten Thousandth

2 – 3 inch





8. _____

130C-18

WORKSHEET, VOLUMES AND AREAS

Calculate the area of squares, rectangles and triangles.

1. Calculate the perimeter and area of a 6" x 6" square.
   P = 2 x length + 2 x width
   A = length x width

2. Calculate the perimeter and area of a 3" x 8" rectangle.
   (use the formulas in the question above)

3. Calculate the area of a triangle, with a 4' base and 5' high.
   A = ½x (base x height)

Calculate the area of a circle and cylinder.

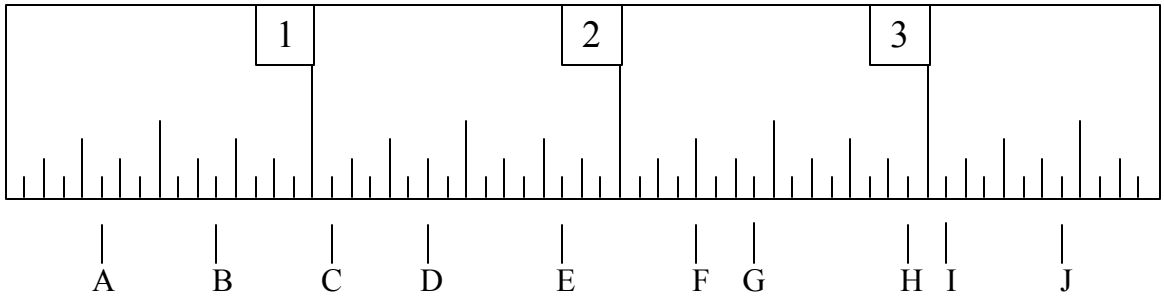
4. Calculate the perimeter and area of a 12" diameter circle.
   Perimeter = ▲ x D
   Area = ▲ x R^2

5. Calculate the perimeter and area of a 3"circle.
   Perimeter = ▲ x D
   Area = ▲ x R^2

6. Calculate the area of a 4" diameter 7" deep cylinder
   Area of a circle = ▲ x R^2
   Area of a cylinder = ▲ x R^2 x height

130C-19

MEASURING EXAM, RULES AND MICROMETERS

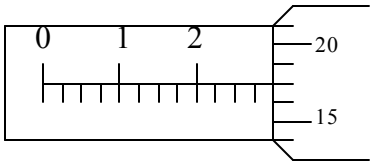


Write down the measurements for the location at each letter

1. A=_____
2. B=_____
3. C=_____
4. D=_____
5. E=_____
6. F=_____
7. G=_____
8. H=_____
9. I=_____
10. J=_____

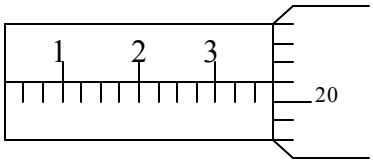
Write down the measurement to the nearest <u>one</u> thousandth.

11. 0 –1 inch



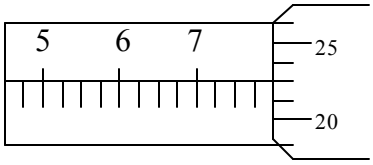
11._____

12. 2 –3 inch



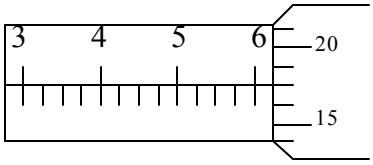
12._____

13. 1 –2 inch



13._____

14. 1 –2 inch



14._____

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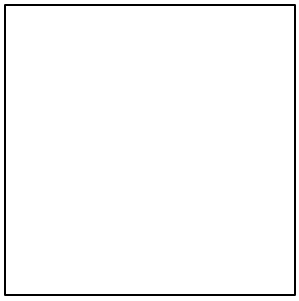
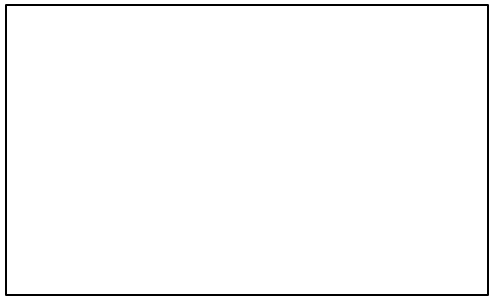
VOLUME AND AREA

Using your ruler, measure the distance around these boxes and calculate the perimeter and area. P= 2 x length + 2 x width A= length x width

15. 

16. 

Perimeter = _____

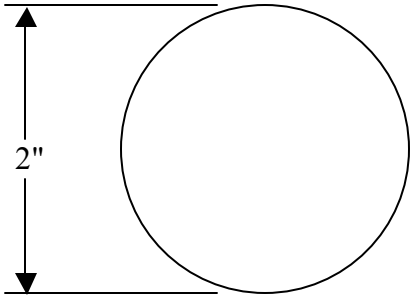
Area in Square inches = _____

Perimeter = _____

Area in Square inches = _____

Calculate the area of a circle. (circle is not to scale)

17. Area in square inches. = _____
Formula: ▲ x R^2



18. Calculate the area of a cylinder, 2 ½ diameter and 3" high.
Formula: ▲ x R^2 x height

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ANSWER SHEET

Worksheet, Ruler

1. 3/8"
2. 13/16"
3. 1"
4. 1, 5/16"
5. 1, 7/8"
6. 2, 3/16"
7. 2, 7/16"
8. 2, 13/16"
9. 3, 1/16"
10. 3, 1/2"
11. 1/2"
12. 1"
13. 1, 7/8"
14. 2, 3/8"
15. 3, 1/8"
16. 4, 1/8"
17. 1, 15/16"
18. 2, 5/8"
19. 1"
20. 3, 5/8"

Worksheet, Micrometer

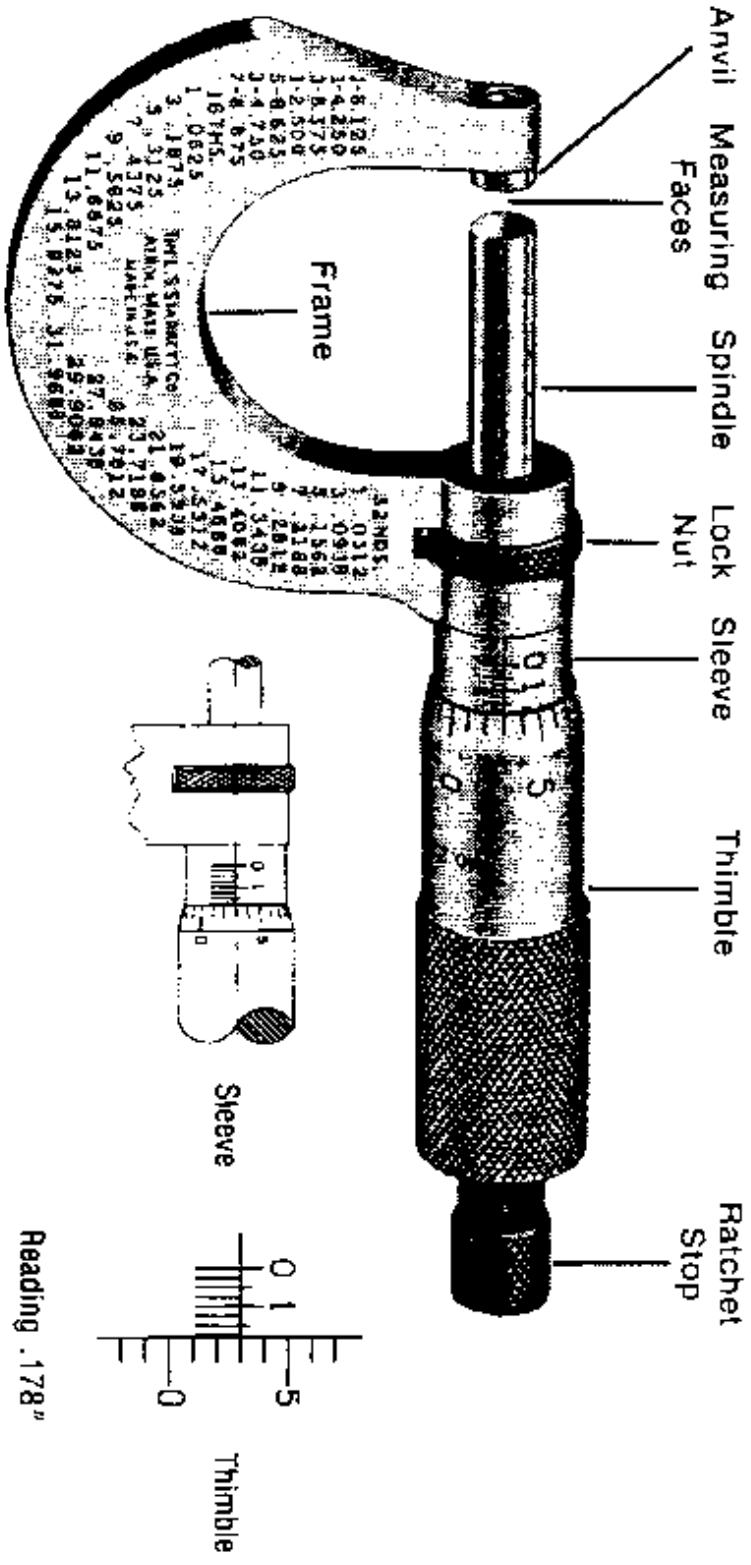
1. 0.921
2. 0.948
3. 1. 624
4. 1.777
5. 0.525
6. 2.394
7. 1.001
8. 2.6483

Worksheet, Volume

1. 24" and 36in^2
2. 22" and 24in^2
3. 10ft^2
4. 37.7" and 113in^2
5. 9.42" and 28.3in^3
6. 351in^3

Measuring Exam

1. 5/16"
2. 11/16"
3. 1, 1/16"
4. 1, 3/8"
5. 1, 13/16"
6. 2, 1/4"
7. 2, 7/16"
8. 2, 15/16"
9. 3, 1/16"
10. 3, 7/16"
11. 0.287
12. 2.371
13. 1.797
14. 1.617
15. 6" and 2 1/2in^2
16. 8" and 3 3/4in^2
17. 3.14in^2
18. 14.71in^2


Anvil
Measuring Faces
Spindle
Lock Nut
Sleeve
Thimble
Ratchet Stop
Frame
Sleeve
Thimble
Reading .178"